The construct of balance control in primary school-aged children: Unidimensional and task-specific

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The construct of balance control in primary school-aged children: Unidimensional and task-specific

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ABSTRACT

The aim of this study was to determine the dimensionality and task-specificity of balance control by investigating the relationships between different tasks and the degree to which these tasks belong to the same construct in primary school-aged children. Seventy-four South African children were randomly selected from a sample of convenience. They performed 18 different balance tasks that were grouped into four balance scales: *the Performance and Fitness (PERF-FIT) static balance score*, the *PERF-FIT dynamic balance score*, the *PERF-FIT* moving cans balance score and the Balance Sensory score. Spearman rank correlations were calculated between the scores. Principal component analysis (PCA) was used to investigate the number of factors within the construct. Moderate to good correlations were found between: i) *PERF-FIT Moving cans balance score* and the *Balance Sensory score* ($r = 0.605$, $p < 0.001$); ii) *PERF-FIT static balance score* and the *PERF-FIT Moving cans* ($r = 0.586$, $p < 0.001$); iii) *PERF-FIT static balance score* and the *Balance Sensory score* ($r = 0.541$, $p < 0.001$). All other correlations were low to fair. The PCA revealed one component. The three PERF-FIT items (moving cans-, static- and dynamic balance score) and the Balance Sensory score explained 59.4% of the variance of total balance performance.

1. Introduction

Adequate balance control allows control of posture and coping with destabilizing forces (Horak, 2006; Huxham, Goldie, & Patla, 2001) and is therefore essential for overall motor development in children (Shumway-Cook & Woollacott, 2017). For a long time, balance control was perceived as a general ability needed for a large variety of different tasks (Horak, 2006; Kiss, Schedler, & Muehlbauer, 2018). This implies that balance performances are strongly interrelated and that one balance tasks predicts the outcome of another. However, a recent meta-analysis provided evidence that this is not the case, shown by small-sized correlations between static steady-state (e.g. bipedal stance), dynamic steady-state (e.g. the 10 m walk test), anticipatory (e.g. the Y-balance test) and reactive (e.g. restoring balance after external perturbation) balance control, indicating that balance control is task-specific (Kiss et al., 2018). To address this task-specificity, several frameworks have been developed to improve our understanding of balance control

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(Horak, 2006; Horak, Wrisley, & Frank, 2009; Huxham et al., 2001; Shumway-Cook & Woollacott, 2017; Verbecque, Lobo Da Costa, Vereeck, & Hallemans, 2015). For example, Huxham et al. (2001) link the task-specificity to characteristics of the base of support, i.e. small versus large, stationary versus moving, predictable versus unpredictable. Shumway-Cook and Woollacott (2017) distinguish three control mechanisms based on the timing relatively to the movement onset corresponding with anticipatory, steady-state and reactive adjustments (Shumway-Cook & Woollacott, 2017). Horak emphasized that balance control is the result of the interaction of multiple sensorimotor processes, and therefore has a multi-systemic nature (Horak, 2006; Horak et al., 2009). To capture this multi-systemic nature, not only the control mechanisms are distinguished, but attention is also given to sensory strategies, cognitive processing, orientation in space and control of dynamics. From this point of view, the type of task determines which aspect of balance is being tapped into.

Such a multi-systemic view implies that comprehensive assessment is needed to address the different subcomponents of balance control, e.g. static, dynamic, anticipatory and sensory orientation (Horak, 2006; Horak et al., 2009; Kiss et al., 2018; Riemann & Schmitz, 2012; Schedler, Abeck, & Muehlbauer, 2021; Verbecque et al., 2015). Indeed, Kiss et al. (2018), evidenced that in children, different subcomponents of balance control (i.e. static, dynamic, online, anticipatory or reactive balance control) are poorly interrelated. Despite the growing support for its task-specificity, there is still unclarity about the construct of balance control. Should it be addressed as one overall construct comprising different types of tasks/subcomponents (unidimensional (Darr, Franjoine, Campbell, & Smith, 2015; Franchignoni, Godi, Guglielmetti, Nardone, & Giordano, 2015)) or rather as a cluster of different constructs (multidimensional (Benka Wallén, Sorjonen, Löfgren, & Franzén, 2016; Verbecque et al., 2015)). Whether or not balance control is uni- or multidimensional might be influenced by the task difficulty with respect to the individual under investigation.

An often-applied task to assess a child's balance, is timed one leg stance (OLS) (Kiss et al., 2018; Riemann & Schmitz, 2012; Verbecque et al., 2015). Its popularity, however, is not surprising, since it is easy to standardize and therefore often administered, reflects daily situations where a child needs to rely on a single leg base of support, e.g. walking, running, hopping, etc., and also forces the control systems to anticipate for a reorganization of the center of mass over a smaller base of support (Riemann & Schmitz, 2012). During timed OLS, the child is asked to stand quietly on one leg for a predefined time period. Whether a child successfully performs this task depends upon his/her developmental stage. For example, most three-year-olds cannot achieve OLS independently (Verbecque, Feys, Vereeck, van de Heyning, & Hallemans, 2018), approximately half of the 6- to 7-year-olds can maintain OLS for 15 s, and until age eight, still less than 90% of the children can successfully achieve and maintain OLS for at least 30 s (Condon & Cremin, 2014).

The difficulty level of OLS can be increased by adding destabilizing factors, e.g. asking the child to move the lifted leg in different directions (Faigenbaum et al., 2014). Adding a dual task, either motor, e.g. asking the child to perform a task with the upper limbs at the same time (Hung, Meredith, & Gill, 2013), or cognitive, a modified Stroop task (Boonyong, Siu, van Donkelaar, Chou, & Woollacott, 2012; Villarrasa-Sapiña, Estevan, Gonzalez, Marco-Ahulló, & García-Massó, 2020), also increases the difficulty level. Using an additional motor task, the demand on both the anticipatory and part of the reactive control system increases. With an additional cognitive load younger children experience more difficulties in successfully performing the balance task compared to older children (Boonyong et al., 2012; Villarrasa-Sapiña et al., 2020), especially when the balance task difficulty increases (Boonyong et al., 2012). Likewise, adding sensory perturbations using foam and eyes closed (EC) conditions can also increase the task difficulty. Indeed, the time to successfully maintain OLS decreases significantly on foam and with EC compared to eyes open (EO) (Condon & Cremin, 2014). Thus, the task-specificity of balance control may be related to the task's difficulty level, depending upon the child's developmental stage.

Apart from the differences between tasks, and developmental influences, cultural or ethnic aspects may play a role as well. Children from Cape Town living in low-resourced areas provide an opportunity to investigate balance control in the absence of structured physical education classes and regular extra-curricular sports activities. This school system focusses more on the required cognitive, social and societal aspects of development than the motor aspect. In contrast to European children, these children have less organized training opportunities, which may hamper their skill development. Physical education is one of the most influential factors for the opportunity of motor skill development in a school setting, because it allows practice opportunities and qualitative instructions and feedback on performance which are essential for motor skill development (Bolger et al., 2020). This specific group of children can therefore help us provide new insights into how different balance tasks are interrelated when children have limited motor experience.

The aim of the present study is therefore to determine the dimensionality and task-specificity of balance control in South African children with low SES, by investigating the relationships between different OLS tasks and whether these belong to the same construct. We hypothesize that OLS with different difficulty levels in both static and dynamic situations would induce fair to moderate correlations, confirming the task-specificity of balance control (Kiss et al., 2018; Riemann & Schmitz, 2012; Schedler, Kiss, & Muehlbauer, 2019). Furthermore, identifying different factors within the construct of balance based on the type of task (static – dynamic – sensory perturbation) would confirm its multidimensional task-specific character. These new insights will enhance the selection of a set of balance tasks that can be used to identify balance deficits in school-aged children, allowing the evaluation of treatment efficacy with respect to different aspects of the construct of balance control.

2. Methods

2.1. Participants

Children aged 6–9 with a low socio-economic status (SES) were recruited from one primary school near the university of Cape Town, South Africa, through convenience sampling. The children participated in this cross-sectional study after their parents provided written informed consent. Data-collection took place between July and August 2019. The study protocol was approved by the local ethical committee (HREC139/2019) and in accordance with the Helsinki Declaration of 1975, as revised in 1983. To control for SES, a quintile two school was selected, where parents pay little/no school fees.

The parent(s) filled in a questionnaire on features of the mother's pregnancy, the child's birth, presence of visual, auditory, cardiorespiratory, intellectual or motor difficulties, established medical diagnoses and use of medication, sports participation outside school and parent-reported difficulties in focusing attention.

Children were excluded from the sample if they had: i) a formal diagnosis that would impede balance, ii) refused testing or iii) incomplete test results due to absence from school during test administration. Neither children nor legal guardians received financial compensation for their participation.

Parental consent was obtained for 111 children. None of the children were excluded due to a formal diagnosis or refusal to participate. Thirty-seven children were excluded from the analyses because of incomplete test results due to absence from school on at least one of the test sessions. The results of 74 children (mean (SD) age: 7.5 (1.0) years old) were used for analyses. Four age groups were composed according to chronological age: “age 6” (children aged 6 years 0 months until 6 years 11 months), “age 7” (children aged 7 years 0 months until 7 years 11 months), “age 8” (children aged 8 years 0 months until 8 years 11 months) and “age 9” (children aged 9 years 0 months until 9 years 11 months). A description of the sample, i.e. sex distribution, weight, height, BMI and MABC-2 classification, is provided in Table 1.

2.2. *Measurements*

2.2.1. *Movement Assessment Battery for Children – 2nd edition (MABC-2)*

The MABC-2, a reliable and valid test for assessing motor performance in children of this age, was administered to assess motor development (Brown & Lalor, 2009; Ellinoudis et al., 2011; Jaikaew & Satiansukpong, 2019). The test contains eight motor tasks divided into three domains: manual dexterity, aiming and catching and balance. Raw scores were converted to standard scores and summed to calculate the overall percentile for each domain. Percentiles can be interpreted as: normal motor development (≥P25), at risk for motor difficulty for which monitoring is required (P5 < x ≤ P16) or significant motor difficulty (≤P5) (Henderson, Sugden, & Barnett, 2007).

2.2.2. *Balance assessment*

2.2.2.1. Balance subscale of the MABC-2. Items of two age bands were used, based on the MABC-2 manual (Henderson et al., 2007). *Age band 1* (3–6 years) assesses OLS on firm surface for both legs (max 30 s per leg), walking with heels raised on a 4.5 m long line (max 15 consecutive steps) and jumping continuously with both feet in squares (max 5 consecutive jumps). *Age band 2* (7–10 years) requires children to perform OLS on a board (max 30 s per leg), walk heel-to-toe on a 4.5 m long line (max 15 consecutive steps) and hop continuously on one leg in squares (max 5 consecutive hops for both legs). The raw item scores were converted to standard scores, the *MABC-2 balance subscale (MABC-2-BS),* and used for analyses.

2.2.2.2. Balance tasks of the Performance and Fitness test battery (PERF-FIT). The PERF-FIT balance skills items series consists of five tasks with increasing difficulty (Smits-Engelsman, Cavalcante Neto, Draghi, Rohr, & Jelsma, 2020). First, the child performed the static balance items: 1) standing and hugging their knee (left and right) for maximum 15 s, followed by grasping their foot (left and right) for maximum 15 s. Timing started when the knee was hugged or the foot was grasped and stopped if the raised foot or leg was fixated to or supported by the standing leg, the child made corrective hops on the supporting foot, the child lost balance or fell. For both items, the child was allowed a second trial if (s)he did not perform maximally during the first trial. The best trial was considered the final result. Subsequently, the scores were summed into a *PERF-FIT static balance score (PERF-FIT-SBS)* with a maximum of 60 s.

Then, the child was asked to walk slowly in an agility ladder (max 8 steps) while hugging a knee or grasping a foot without touching the borders, stepping outside the borders or losing balance. For both items, the child was allowed a second trial if (s)he did not perform maximally during the first trial. For each item, the best trial was considered the final result. Subsequently, the scores were summed into a *PERF-FIT dynamic balance score* (PERF-FIT-DBS) with a maximum of 16 steps.

During the last series, the child had to pick up 4 cans consecutively and move them from far to close (or the other way around) while

Table 1
Description of the included sample.

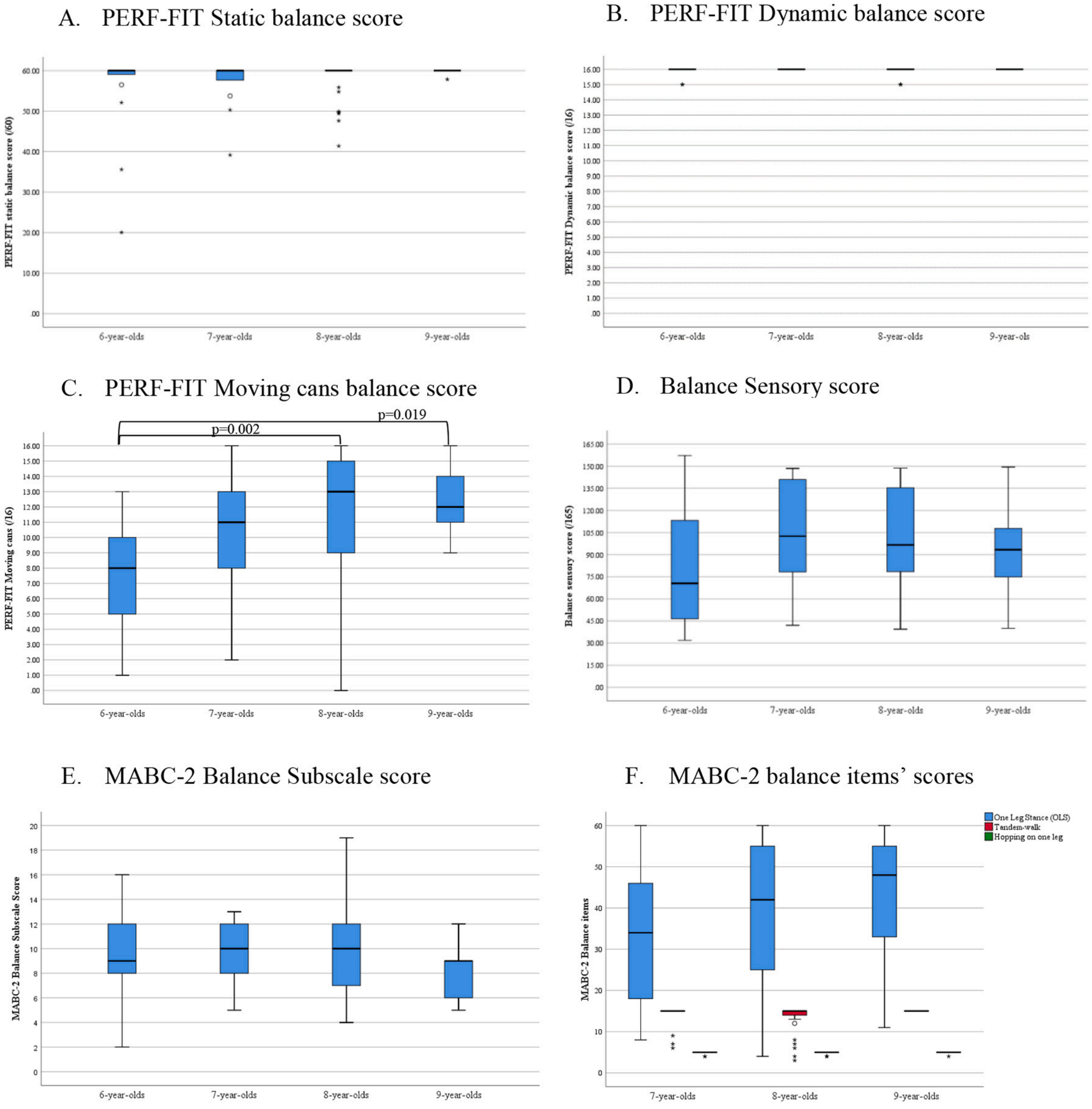
		All children	Age 6	Age 7	Age 8	Age 9
Boys/Girls	*(n/n)*	33/41	7/11	5/9	14/19	7/2
Weight (kg)	*Mean (SD)*	27.2 (5.6)	23.7 (3.4)	26.4 (5.4)	28.4 (5.5)	30.9 (6.7)
Height (cm)	*Mean (SD)*	129.1 (7.6)	120.8 (5.0)	127.1 (6.7)	132.8 (5.0)	135.9 (4.9)
BMI (kg/m^2)	*Mean (SD)*	16.2 (2.3)	16.2 (1.6)	16.3 (2.2)	16.0 (2.3)	16.7 (3.3)
MABC-2 (percentile (P))	*Mean (SD)*	45.3 (30.5)	45.8 (29.7)	46.1 (28.8)	48.8 (33.3)	30.6 (23.1)
≥ P25	*(n (%))*	54 (73.0)	14	11	24	5
P16 ≥ x > P5	*(n (%))*	11 (14.8)	2	2	4	3
≤P5	*(n (%))*	9 (12.2)	2	1	5	1

Percentiles can be interpreted as: normal motor development (≥P25), at risk for motor difficulty for which monitoring is required (P5 < x ≤ P16) or significant motor difficulty (≤P5).

performing OLS without moving the stance foot, losing balance or placing the raised leg on the ground. One point was earned for each correctly placed can (max 4 points). The children performed this for both legs and in both directions (i.e. 4 items). The *PERF-FIT moving cans balance score* (PERF-FIT-CBS) equals the sum of the four items (max 16 points). The PERF-FIT is a valid test to measure movement skills, musculoskeletal fitness and agility in children this age in low resourced communities (Smits-Engelsman et al., 2020).

2.2.2.3. Balance tasks with sensory perturbation. The item “Standing heel-to-toe on a balance beam” of the Bruininks-Oseretsky Test – 2nd edition was selected to induce a narrowed base of support. The child stood with the preferred leg behind the non-preferred leg with the hands on the hips. Three trials were allowed instead of two (Bruininks & Bruininks, 2005). The trial ended if the child was unable to maintain the heel-to-toe position, the hands on the hips or stepped or fell of the beam. The median time 8- to 9-year-old children can maintain tandem stance on a foam pad is 45 s (Condon & Cremin, 2014). As such, to allow more variance in the performances, the time was recorded until 45 s (instead of 10 s (Bruininks & Bruininks, 2005)). The best time was the final result.

The children also performed two OLS tasks: 1) on foam with EO and 2) on foam with EC. The children were instructed to take place on the foam pad with one foot, keep their hands next to their body and raise the other leg (and subsequently close their eyes). Three trials were allowed for each foot with EO (maximum 45 s). The EC condition was performed exclusively on the preferred leg (maximum 30 s). A trial was ended if the child was unable to maintain the unipedal position, showed excessive arm, trunk or hip movements, stepped or fell of the foam. The best time recorded was the final result for each condition. The item scores were then summed into the


A. PERF-FIT Static balance score

B. PERF-FIT Dynamic balance score

C. PERF-FIT Moving cans balance score

D. Balance Sensory score

E. MABC-2 Balance Subscale score

F. MABC-2 balance items’ scores

Fig. 1. Distribution of the balance scores for the different age groups.

Balance Sensory score (BSS, max score of 165 s).

2.3. Statistical analysis

Demographic data (age, sex, weight, height, BMI, MABC-2 percentile) were used to describe the sample.

Outcome measures were checked for normality with the Shapiro-Wilk test. Descriptive statics, mean and standard deviations were used to describe the sample. Differences in balance performance distribution between age groups were investigated with the Kruskal-Wallis test. Multiple post-hoc comparisons between the four age groups (age 6, 7, 8 and 9) were corrected for using Bonferroni correction. Significance was set at $p < 0.05$. Relationships between the different balance scales were investigated with Spearman's Rank-order correlation coefficients and interpreted as follows: little to no relationship ($r = 0.00$–0.25), fair ($r = 0.25$–0.50), moderate to good ($r = 0.50$–0.75) or good to excellent ($r > 0.75$) (Portney & Watkins, 2009). As the *MABC-2-BS* is a standard score, corrected for age, the different balance scales were also correlated to the three MABC-2 balance tasks' raw scores (OLS, walking, hopping). For this sub-analysis, the 6-year-olds were excluded since their tasks differed from the other age groups.

To determine whether the balance scales measure the same construct, principal component analysis (PCA) with varimax rotation was used. Orthogonal factor scores were derived based on a correlation matrix, with a minimum eigenvalue for extraction set at 1. Scree plots, total variance explained, component matrix, rotated component matrix and transformation matrix were investigated. Minimum loadings of 0.4 per item were considered relevant. The raw values of the *PERF-FIT-SBS,* the *PERF-FIT-DBS,* the *PERF-FIT-CBS* and the *BSS* were included in the PCA. The MABC-2-BS was not used as this combines different tasks into a single score and uses converted scores. Statistical analyses were performed with SPSS 25.0 for windows.

3. Results

3.1. Balance performance

The balance performances are shown in Fig. 1. There were no differences for any of the balance tasks between the age groups, except for the *PERF-FIT-CBS* (Kruskal-Wallis test, $p = 0.002$). Pairwise comparison revealed a difference between ages 6 and 8 ($p = 0.002$) and between ages 6 and 9 ($p = 0.019$).

3.2. Relationships between balance tasks

Moderate to good relationships were found in the age group 6–9 between the *PERF-FIT-CBS* and the *BSS* ($r = 0.605$, $p < 0.001$) and between the *PERF-FIT-SBS* and the *PERF-FIT-CBS* ($r = 0.586$, $p < 0.001$) on the one hand and the *BSS* ($r = 0.541$, $p < 0.001$) on the other hand. The other relationships were fair to little as shown in Table 2.

3.3. Dimensionality of balance performance

The PCA revealed one component, explaining 59.4% of the variance in balance task performance. The variables loaded as follows: *PERF-FIT-CBS* (0.867), *PERF-FIT-SBS* (0.782), the *BSS* (0.717) and the *PERF-FIT-DBS* (0.705).

4. Discussion

To investigate the dimensionality and task-specificity of balance control, different OLS tasks were administered in randomly selected 6- to 9-year-old South African children. As hypothesized, the different types of OLS tasks (Kiss et al., 2018; Riemann & Schmitz, 2012; Schedler et al., 2019) (either static or dynamic) correlated fairly to good with each other. But only two balance scales,

Table 2
Relationships between the different balance scores.

	PERF-FIT static balance score		PERF-FIT dynamic balance score		PERF-FIT moving cans score		Balance Sensory score	
	rho	*p*-value	rho	*p*-value	rho	*p*-value	rho	*p*-value
All children (age 6–9, $n = 74$)								
PERF-FIT static balance score (seconds)								
PERF-FIT dynamic balance score (#)	**0.475**	**<0.001**						
PERF-FIT moving cans score (#)	**0.586**	**<0.001**	**0.388**	**0.001**				
Balance Sensory score (seconds)	**0.541**	**<0.001**	**0.254**	**0.032**	**0.605**	**<0.001**		
MABC-2 balance subscale score (SS)	0.149	0.205	−0.025	0.830	**−0.298**	**0.010**	**0.244**	**0.039**
Age 7–9 ($n = 56$)								
MABC-2 balance OLS (seconds)	**0.392**	**0.003**	**0.276**	**0.040**	**0.268**	**0.046**	0.263	0.055
MABC-2 balance Walking on a line (#)	0.175	0.198	0.090	0.512	0.118	0.385	0.099	0.474
MABC-2 balance hopping (#)	0.080	0.560	−0.082	0.546	0.133	0.329	0.166	0.229

Bold values represent signficant correlation coefficients.

the *PERF-FIT-CBS and the BSS*, correlated significantly with the *MABC-2-BS*. Nevertheless, all balance scales belong to the same construct as only one factor was identified.

The only task being sensitive to age effects was the *PERF-FIT-CBS*. The *PERF-FIT-SBS and PERF-FIT-DBS* have little to no spread in the data (Fig. 1), suggesting these tasks are fully controlled by the age of 6. The *PERF-FIT-SBS* comprises 15 s OLS, while holding the knee flexed to the body or grasping the foot. In European samples, when children perform timed OLS on a stable surface, while keeping their hands on their hips, 50% is able to maintain this position for 15 s or more (Condon & Cremin, 2014; Lundgren, Nilsson, Ringsberg, & Karlsson, 2011; Schedler et al., 2019). As more than 90% of the children in our study reached a submaximal score, it seems that the OLS tasks of the *PERF-FIT-SBS* are easier than OLS with the hands on the hips. For the *PERF-FIT-DBS* all but two children were able to perform maximally on this scale, indicating these tasks are the easiest.

Furthermore, the *BSS* and the *PERF-FIT-CBS* showed more variability, indicating higher difficulty levels. The *BSS* was not influenced by age (Fig. 1), using the median values for comparison. However, none of the age groups reached the maximum score and the spread of the data is also different among age groups, indicating these children do not yet master these tasks. Attention may have played an important role in performance, as maintaining OLS for 45 s is a long time. Especially OLS with EC was very difficult for the majority of the children, which is in line with literature (An, Yi, Jeon, & Park, 2009; Condon & Cremin, 2014). Standing on foam with EC, forces the children to reweight all the available information, making them rely more on vestibular information, which is clearly still challenging for these children and has been suggested to continue developing until age 15 (Morlet, 2013). Clearly, regardless of age, multiple sensory perturbations are difficult to cope with (An et al., 2009) and should be addressed during assessment as these tasks allow clinicians to determine whether children are able to weigh the sensory information adequately. In contrast, the *PERF-FIT-CBS* did reveal age-related differences, distinguishing the 6-year-olds from the older children. Half of the youngest children had difficulties with performing this task (Fig. 1C). Moving the cans while maintaining balance in the OLS position, does not only require adequate balancing, but also strength, flexibility, proprioception, coordination and concentration, which is in line with similar research using the Y-balance test (Faigenbaum et al., 2014; Schedler et al., 2021).

Our study confirmed the task-specificity of balance control shown by the fair to moderate correlations among the different balance scales. Interestingly, the *MABC-2-BS* showed a little to fair relationship with the balance scales or none at all. This might be due to the nature of the scores, i.e. norm-referenced scores that are not validated for South African children. We therefore investigated the relationships with the three balance tasks, showing that in 7- to 9-year-old children, only OLS and not the walking and hopping correlated fairly to the PER-FIT balance subscales. This is probably because variability in the data for these specific items was absent (Fig. 1F) indicating they are easy to perform for the majority of the children. Perhaps highly dynamic tasks, such as walking as fast as possible or running, might have induced a different outcome. For example, the *MABC-2-BS* correlates fairly ($r = 0.42$, $p < 0.01$) with the Test of Gross Motor Development, 2nd edition - locomotor subscale in 5- to 8-year-old children (Logan, Robinson, Rudisill, Wadsworth, & Morera, 2014) and with the modified Timed Up and Go test in 3- to 5-year-old children ($r = -0.347$, $p = 0.007$) (Hallemans, Klingels, Van Criekinge, Vereeck, & Verbecque, 2020). Future research is needed to establish the relationship between these balance scales and scales representing highly dynamic tasks.

All selected tasks required anticipatory and reactive control to some extent. Differentiation of balance factors or dimensions based upon the underlying mechanisms was therefore not expected. The expected multidimensionality based on the type of task (static – dynamic – sensory perturbation) was not confirmed. Although the tasks differed in difficulty levels, they all loaded together, indicating that task difficulty does not induce multidimensionality within the construct of balance. These results confirm the previously reported unidimensionality of balance control in children (Darr et al., 2015). Nevertheless, similar to the tasks used by Darr et al. (2015), our OLS tasks all required anticipatory control and sensory orientation, but not reactive control or control of highly dynamic tasks. In future research it needs to be disentangled if adding such tasks would reveal multidimensionality of balance control, as is suggested by the frameworks defining its multi-systemic nature.

The results of the current study show that even though different types of tasks belong to the same construct, not all tasks measure the same (only fair to moderate correlations). Therefore, these findings are of clinical importance. Given its task-specificity, balance control needs to be assessed with more than one task (Kiss et al., 2018; Riemann & Schmitz, 2012; Verbecque et al., 2015). The lacking age effects may be attributed to the nature of the tasks, indicating the use of a cut-off value (a criterion) to determine whether a child's balance control is insufficient. In these cases, the 5th percentile would be suitable, allowing the identification of the 5% weakest performances. However, whether this method is valid and accurate needs further research. The age-effects found for *PERF-FIT-CBS* indicate that norms need to be established. For children aged 6, the *PERF-FIT-SBS and PERF-FIT-DBS* combined with the balance sensory scale are of interest. Once normative data are available for the *PERF-FIT-CBS*, children above age 6 may start with these balance tasks and if they underachieve, further assessment with easier tasks is needed to determine the extent of their balance deficit.

4.1. Study limitations

The children in the present study were recruited from local low resource schools in Cape Town. Although this allowed us to investigate balance performance without the interference of sports- and stimulating leisure activities, 27% of the children scored at or below the 16th percentile of the MABC-2, which is 11% more than expected. This indicates that the MABC-2 is population-specific. Hence, adjusted tools, e.g. the PERF-FIT, with context-specific norms are needed (Smits-Engelsman et al., 2020). The findings with respect to balance control might also be influenced and cannot be generalized to peers in countries where structured physical education and regular sports participation are the rule. Nevertheless, based on other existing literature (Darr et al., 2015; De Kegel et al., 2010), a similar trend with respect to correlations and construct might be expected in other populations (e.g. European children), despite different raw task performance. Another limitation is the selection of the balance tasks. Only self-induced balance disturbances were tested and highly dynamic tasks were missing in our item set. Also, we did not record the time needed to achieve the correct posture, allowing children as much time as needed, which differs from ADL tasks.

5. Conclusion

Our selection of balance tasks is low to moderately interrelated, indicating a degree of task-specificity, but also covers approximately 60% of the variability within the construct of balance control in children between 6 and 9 years of age.

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Ethical approval

The study protocol was approved by the local ethical committee (HREC139/2019) and in accordance with the Helsinki Declaration of 1975, as revised in 1983.

Informed consent

Informed consent was obtained from all parents of the children included in the study.

Declaration of interest

None.

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